Safe Handling of Beryllium and Its Compounds

Introduction

Although solid beryllium (Be) poses no health hazard, inhaling Be particulates (such as dust, mists, or welding fumes) can produce acute or chronic lung disease, which can be fatal. Based on animal data, Be is classified as a suspect carcinogen by the International Agency for Research on Cancer (IARC), American Conference of Governmental Industrial Hygienists (ACGIH), and National Institute of Occupational Safety and Health (NIOSH), but this is not yet verified by data on humans. Skin irritation may result from direct contact with soluble Be compounds, and healing is impaired in Be-contaminated wounds. Metallic Be powders are a moderate fire hazard, and hazardous concentrations may be released by heating metallic Be above 650°C or by heating Be oxide above 1540°C.

The objectives of this supplement and the safety procedures described here are to eliminate unnecessary Be exposure and reduce exposure to levels well below Occupational Safety and Health Administration (OSHA) regulations. Controls that apply to the handling of metallic Be alloys, Be oxide and hydroxide, salts, and any other Be compounds are described below. An Operational or Facility Safety Procedure (OSP or FSP) is required for all processing of Be that is likely to generate dusts, mists, fumes, or small particulates.

All operations that will produce a release of Be to the atmosphere must be reviewed by the Environmental Protection Department for possible air-permitting requirements. Beryllium is regulated under the Clean Air Act by the U.S. Environmental Protection Agency as a hazardous air pollutant and by the State of California as a toxic air contaminant.

Engineering Controls

- Cutting, grinding, machining, sanding, or processing of solid Be should be done wet whenever possible to control Be particulates at the source. Local, ventilated contaminant enclosures are also required. Hazards Control must review the design and air flow of such contaminant enclosures to ensure that they meet the design criteria of the ACGIH's current *Industrial Ventilation, A Manual for Recommended Practice*. Typical air-flow requirements are 100–125 linear ft/min for fume-hood enclosures and 300 cfm/ft^2 of opening for machine enclosures. Before replacing or installing new contaminant enclosures, the project must be reviewed by the Environmental Protection Department's Environmental Evaluations Group to determine the level of National Environmental Policy Act (NEPA) documentation. Contact the environmental analyst for your area Safety Team to initiate the NEPA review process.

- Exhaust from routine Be-processing operations that could produce airborne particulates must be vented to the environment through an approved high-efficiency particulate air (HEPA) filter.

- Ventilation systems will be evaluated annually under actual operating conditions to ensure proper air flow at each workstation. For work areas that routinely process Be (i.e., at least monthly), visual indicators such as audible alarms, telltale power lights, or flow indicators should be installed at each work station to show that the ventilation is operating properly.

- Be-contaminated parts and equipment must be contained. This may be done using plastic bags or by taping over all exposed surfaces.

- When entire laboratories are designed as Be work areas, they shall be maintained at a negative pressure with respect to adjacent areas to prevent the migration of contamination. Contamination should be confined to the smallest area feasible, and the walls and floor should be made of smooth, nonporous material for easy decontamination.

- Because Be is a good neutron moderator and reflector, the amount of fissile material

in the work area shall be restricted and must be specified in applicable OSPs.

- Any device that is used to abate effluents from a potential source of Be emissions must be evaluated for air-permitting requirements. It should be noted that an authority-to-construct permit is required prior to construction of any air-pollution abatement device.

Personnel Controls

- The need for various types of protective clothing for Be operations must be reviewed by Hazards Control. Such clothing must also be specified in the applicable OSP.

- Protective clothing (e.g., coveralls, lab coats, or shoe covers) will be based on the work conditions and expected contamination levels. Typically, a lab coat and gloves are the minimum protection needed. Upon leaving the processing area, workers must remove protective clothing and discard it as toxic waste or segregate and mark it as Be-contaminated laundry.

- Impermeable gloves must be used to avoid skin contamination, and open wounds must be covered.

- Smoking, drinking, or eating is not allowed in a Be-processing area. Storing tobacco, beverages, and food is also prohibited.

- Following work operations, workers must wash their hands. Depending on the nature of the work and facility procedures, showering may also be required.

- Significant spills involving particulates or liquids should be promptly cleaned up using the appropriate protective equipment selected by Hazards Control. See Table 1 for emergency actions in Be accidents.

- Respiratory protection should not be a substitute for engineering controls, except while engineering controls are being implemented or for emergency use. Contact Hazards Control for assessment of need for respiratory protection, and obtain medical approval for potential users (see Chapter 10 of this manual). Acceptable respirators for Be work are listed in Table 2.

Administrative Controls

- All Be processing that is capable of generating fine particulate contamination requires an OSP to address the hazards and identify appropriate controls. Examples of such processes are cutting, machining, welding, or decontamination of Be and its compounds or alloys. For an FSP to substitute for an OSP, the FSP must specifically identify the Be process(es), location(s), and all controls in detail. No OSP is required for work with Be-alloy parts that contain less than 2 percent Be (such as electrical

Table 1. Emergency actions in Be accidents.

Eyes:	**If Be powder or chips get into eyes, do not rub them. Flush eyes with water for at least 15 min, lifting the upper and lower eyelids frequently to ensure complete washing. Have someone else dial 911 for the emergency dispatcher.**
Skin:	**If Be powder or chips come in contact with an open wound in your skin, flush the wound with water for 10 min and report to Health Services.**
Inhalation:	**If you have inhaled, or think you have inhaled, Be dust, report to Health Services. Have someone else notify Hazards Control.**
Spills:	**If Be powder is spilled, evacuate and isolate the area. Move upwind, if possible, and wear an air-supplied respirator or a cartridge respirator equipped with a high-efficiency dust filter or the equivalent. If it is practical, wet down the spill with water and cover it with sand, a tarpaulin, or some other suitable material. Dial 911 for the emergency dispatcher. Hazards Control will specify the procedures and protective equipment to be used in cleanup and decontamination.**

contact strips or springs) as long as no grinding or filing is done.

- The 8-hr, time-weighted average permissible exposure limit (PEL) specified by OSHA is 2.0 $\mu g/m^3$. To assure that airborne Be levels are maintained below this limit, administrative controls for air and surface contamination have been established (see Table 3), as well as maximum environmental contamination levels (see Table 4).

- Personnel monitoring and an area sampling plan are required for all Be processing capable of generating fine particulates. Initial personnel air monitoring at the start of the operation is required, and periodic monitoring will follow based on the initial results. Swipe samples of the area should also be collected routinely to evaluate cleanliness. Hazards Control will collect these samples and report sample results. Supervisors must assure that sampling is performed and corrective actions are implemented.

- Supervisors are required to annually identify and document for Health Services those workers who have a reasonable potential

Table 2. Acceptable respirators for Be work and conditions for their use.

Respirator	Condition for use
Self-contained or air-line equipment, positive pressure-demand valves only. Wearer must be trained in their use.	**Unknown concentration or with concentration greater than 100 $\mu g/m^3$.**
Full-face mask with chin-type high-efficiency filter. Wearer must be trained and properly fitted.	**Known concentration of less than 100 $\mu g/m^3$.**
Half-mask with high-efficiency filter. Wearer must be properly fitted and know which respirator to use.	**Known concentration of less than 20 $\mu g/m^3$.**
Powered air-purifying respirators:	
Tight-fitting facepiece with appropriate filter or cannister	**Known concentrations less than 100 $\mu g/m^3$.**
Hood or helmet	**Known concentrations less than 50 $\mu g/m^3$.**

Table 3. Maximum administrative permissible levels for Be-processing areas.

Type	Level	Condition	Action required
Air (8-hr average)	**<0.2 $\mu g/m^3$**	**Normal**	**None.**
	0.2–2.0 $\mu g/m^3$	**Warning**	**Investigate cause and correct.**
	>2.0 $\mu g/m^3$	**Limit exceeded**	**Stop work and investigate cause.**
Surface contamination	**<0.01 $\mu g/cm^2$**	**Clean**	**None.**
	0.01–0.03 $\mu g/cm^2$	**Permissible**	**Only for designated Be-processing area.**
	0.03–2.0 $\mu g/cm^2$	**Warning**	**Decontaminate, investigate, and correct.**
	>2.0 $\mu g/cm^2$	**Limit exceeded**	**Stop work, decontaminate, investigate, and correct.**
OSHA 8-hr PEL	**2.0 $\mu g/m^3$**	**—**	**—**

Table 4. Background and maximum permissible environmental contamination levels (uncontrolled area guidance provided by LLNL's Environmental Protection Department).

Medium	Maximum allowable	Natural Be occurrence
Air	0.01 μg/m^3 [a] averaged over 30-day period	1.0×10^{-4} μg/m^3 [b] (suburban/rural areas)
Surface water	11.0 μg/l soft water[c] 1100.0 μg/l hard water	0.19 μg/l (detected in 5% of waters)
Drinking water	6.8×10^{-3} μg/l [d] (detected in 1% of waters)	0.1 μg/l [e]
Soil	2.0 μg/g [f]	0–3.0 μg/g [g]

[a] 40 CFR Part 61.32, *Beryllium Emission Standard, 1985*. Also, Bay Area Air Quality Management Board.
[b] *Beryllium—A Potential Environmental Contaminant*, Wilber, American Lecture Series No. 1040 (1980).
[c] *Water Quality Criteria for Water*, Environmental Protection Agency, Washington, DC (1976) (guidance only for Be salts in water).
[d] U.S. Environmental Protection Agency, National Ambient Water Quality Criteria in *Phase II Recommended Maximum Contaminant Levels (RMCLs)*, from State Water Resources Control Board Resolution No. 85-26.
[e] *Drinking Water and Health*, Safe Drinking Water Committee, National Research Council, National Academy of Sciences (1977).
[f] Memo from Steve Tochilin to Owen Van Dyke (1980), "Review of Site 300 Beryllium Sampling Program." Standards were developed in-house to assess contamination control.
[g] Mason and Moore, *Principles of Geochemistry*, 4th ed. (New York, John Wiley & Sons, 1982), p. 176.

for Be exposure, as recommended by the Industrial Hygiene Group of Hazards Control. These workers are defined as individuals who directly perform work that could generate Be dust or who routinely work in the same local area where such processing occurs. These workers shall complete the training courses for Be work as specified in LLNL's *Training Program Manual.*

- Hazards Control will notify the employee, the supervisor, and Health Services of known or suspected overexposure to Be (i.e., airborne levels greater than 2.0 μg/m^3 averaged over an 8-hr day or greater than 5.0 μg/m^3 for any period) and of suspected contaminated injuries.

- Decontamination of areas and equipment must be performed regularly to control contamination buildup. Only wet wipes, wet floor mops, and vacuums equipped with HEPA filters shall be used. Work shall be stopped when surface contamination exceeds 2.0 μg/cm^2, and the area will be cleaned.

- Equipment to be sent to Hazardous Waste Management for decontamination or disposal shall be tagged to indicate Be contamination, including potential internal contamination.

- Entrances to Be-processing areas shall be posted with a warning sign to indicate the possible presence of Be contamination (see Fig. 1).

- Warning labels must also be used to identify Be pieces or their containers and equipment that is potentially contaminated (see Fig. 2).

- Maintenance and repair of potentially contaminated equipment must be performed with controls to prevent exposure and spread of Be contamination. Notify Hazards Control before doing such work.

- All Be-contaminated waste must be placed in properly marked containers supplied by Hazardous Waste Management. Refer to Chapter 9.0 of the *Environmental Compliance Manual* and contact Hazardous Waste Management (ext. 3-4806) if you have any questions about disposing of beryllium waste..

- All Be and Be-contaminated waste must be placed in an appropriate waste container and labeled with a hazardous waste label. The State of California regulates waste containing Be when the concentration of Be exceeds either 75 mg/kg total or 0.75 mg/l in an extract from the waste.

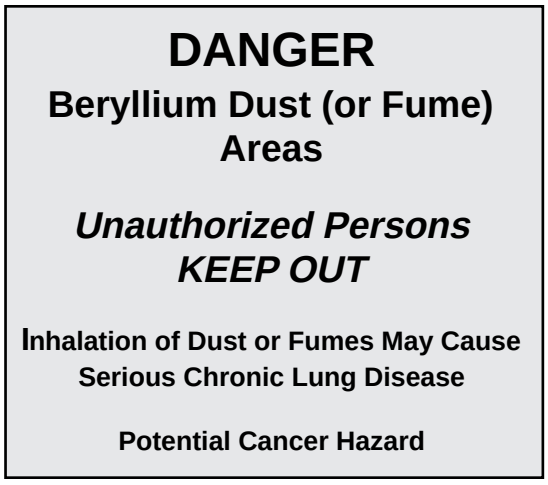

Figure 1. This warning label (available from your area Safety Team) shall be applied to all shipping and storage containers or packages containing Be compounds where exposure to dusts, fumes, powders, or liquids is likely to occur.

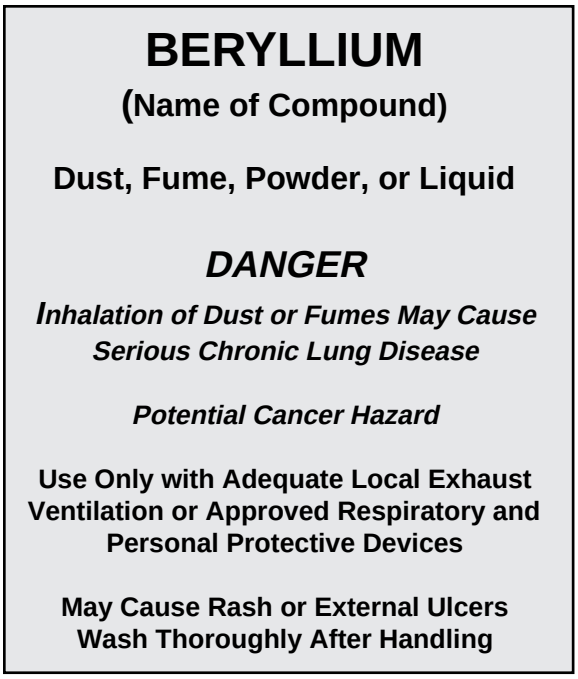

Figure 2. This warning sign (available from your area Safety Team) shall be affixed in a readily visible location on processing and other equipment, on storage bins and tanks, and at or near entrances and areas where exposure to dusts or fumes of Be and Be compounds is likely to occur.

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Appendix A

Materials Management Controls for Beryllium

Responsibilities

The custodians of the Materials Fabrication Division vault in Building 321 and the Materials Management Division vaults in Buildings 131 and 231 are responsible for ensuring that Be consigned to their respective vaults is properly received and records are properly maintained. Custodians of the three vaults are responsible for verifying that all containers, items, serialized parts, etc., are received as listed on the accompanying packing slip and the receipt record of the purchase order. Vault custodians must also ensure that labeling and packaging for Be storage conform with LLNL *Health & Safety Manual* requirements and LLNL Protective Services Department regulations.

Receipt of Beryllium

The Supply and Distribution Department's Receiving Group accepts, screens, and separates all items from outside suppliers. This group delivers unopened packages containing Be to a vault, as determined by the "Deliver To" block on the purchase order. Special Materials and/or Purchasing personnel must list the requester and the correct address on both the original and receipt copy of the purchase order according to the section entitled "Mailing Addresses for Classified Matter" of LLNL's *Security Manual*.

Consignee Designation

All Be and mixed Be shipments (i.e., those mixed with nuclear materials) must be consigned to the Materials Management Division. In addition, the requester's original job order should specify the Building 131 vault receipt or Building 321 vault receipt if the Be is to enter the Materials Fabrication shops for machining, inspection, or assembly. Beryllium orders from all other areas of LLNL should specify delivery to the central vault in Building 231. If the building address is not indicated, the Be will be sent to the vault in Building 321.

On-Site Transfer of Beryllium

From the Building 231 vault, mechanical shops, or Building 131 vaults, the vault custodians will notify the requester when the Be arrives and make arrangements for its physical transfer. No Be can be released until the Protective Services Department regulations and Hazards Control packaging and labeling requirements have been met.

Transfer of Beryllium Between Livermore and Site 300

Materials Management personnel at Livermore or the Process Area Coordinator at Site 300 authorize the transport of all Be. No Be may be moved unless the requester notifies these authorities in advance. The Identification Tag for Controlled Material (form LL-3076) and precautionary labeling requirements must be used to transfer Be between groups.

External Shipments of Beryllium

Only Materials Management is authorized to process external shipments of Be directly to the Supply and Distribution Department's Shipping Group. Any other group with Be to be shipped from LLNL must transfer it to the central vault in Building 231 for processing. Instruction No. 1 of LLNL's *Procurement Guide* states that all Be shipments of commercial purchase orders are subject to prior approval by the Purchasing Department and that all shipments of Sandia National Laboratories' purchase orders are subject to prior approval by the Special Materials staff. The vault custodian must ensure that a shipment complies with Department of Transportation requirements and must arrange for its transport with the Supply and Distribution Department.

Disposal of Beryllium Waste

All Be-contaminated waste must be placed in properly marked containers supplied by Hazardous Waste Management. Contact Hazardous Waste Management (ext. 3-4806) if you have any questions about disposing of beryllium waste.